The Impact of Different Instructor Participation Approaches in Asynchronous Online Discussions on Student Performance

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Abstract
Instructor participation plays a crucial role in asynchronous online discussions, as the approach taken can potentially impact student performance. This study compared two instructor participation approaches: replying to student posts on public discussion boards and commenting on student posts on private grade pages. It examined the impact on both the quantity of student participation and the quality of student posts. The findings revealed more student-student interactions when the instructor replied directly on discussion boards compared to when the instructor commented on private grade pages, despite both approaches leading to an interconnected social network. The number of student posts and the overall quality of student posts did not show a significant difference between the two approaches. Nonetheless, both approaches contributed to a gradual improvement in the quality of student posts over time. Additionally, when the instructor commented on grade pages, students' focus shifted gradually from social communication to knowledge construction in their posts.

Keywords: asynchronous online discussion, instructor participation approach, student performance, content analysis, social network analysis

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Asynchronous online discussion (AOD) is a widely adopted learner-centered activity in higher education in both online and blended learning. It allows students to access a shared virtual space to discuss learning materials, share resources and personal experiences, engage in communication and collaboration, and receive feedback from peers and instructors. AOD supports the three essential types of interaction in online learning proposed by Moore (1989): student-content, student-student, and student-instructor. Its asynchronous nature enables students to participate at their convenience, accommodating those with work or family commitments. This flexibility also allows students more time to process information, reflect on learning content and others' perspectives, and develop thoughtful responses (Berry, 2005; Rainsbury & Malcolm, 2003). AOD promotes equitable participation, benefiting students who may be reluctant to speak in real-time settings. For instance, non-native English speakers (Rainsbury & Malcolm, 2003) and female students (Arbaugh, 2000) often engage more in AODs than classroom discussions. This inclusivity brings diverse perspectives and ideas into the discussions (Comer & Lenaghan, 2013). Additionally, the online environment of AODs allows students to enhance their contributions with multimedia resources such as images, audio, videos, and files, enriching the shared information.

Beyond these advantages, AOD has been extensively studied and found to promote student engagement (Parks-Stamm et al., 2017; Shi et al., 2023; Xu et al., 2020), knowledge construction (Gao et al., 2013; Martono & Salam, 2017), active learning (Baker et al., 2005; Murphy, 2004), critical and higher-order thinking (Aloni & Harrington, 2018; Frijters et al., 2008; Kwon et al., 2019; Meyer, 2003; Sautter, 2007; Smith, 1977), and reflection (Decker & Beltran, 2016; Hara et al., 2000). However, the success of AODs depends on careful design and facilitation, with instructor participation being crucial. A systematic review by Xie and Correia (2024) of 25 studies on instructor participation in AODs revealed a focus on the frequency and types of instructor comments and their mixed effects on student participation, achievement, emotions, and learning time. There is limited research on specific instructor participation approaches in AODs and their impact on student performance (Dennen, 2005). Further research is needed to enhance the effectiveness and efficiency of AODs and improve students' overall online learning experience.

Asynchronous Online Discussions

AOD is a powerful tool for online learning in higher education (Hammond, 2005), promoting student-student and student-instructor interactions conducive to knowledge construction and learning communities (Fehrman & Watson, 2021). According to the literature review conducted by Hammond (2005), which examined 62 studies on AODs in higher education from 2000 to 2004, learners reported that they highly value the social support they receive from discussions, which motivates them to learn. Additionally, posts from peers and instructors often trigger their reflections. Many factors can influence the effectiveness and efficiency of AODs, with numerous studies focusing on the design of AODs and the facilitation strategies employed.

Design of AODs

Hammond (2005) classified AODs into three types: open, loosely structured, and cooperative/collaborative task-based. Open AODs are mostly unstructured discussions with no

clear guidelines and no strict requirements for student participation. In loosely structured AODs, students are required to post their own thoughts on some specific topics in discussions, such as reflections on learning materials or analyses of case scenarios. Cooperative/collaborative task-based AODs focus on teamwork, where students work in small groups to discuss and complete learning tasks.

In their systematic review of 35 studies from 2015 to 2019, Fehrman and Watson (2021) simply divided AODs into unstructured and structured. They specified that structured AODs with clearly defined goals and expectations or guiding questions could improve students' learning outcomes, resulting in more posts, deeper thinking, and positive attitudes compared to unstructured AODs. Similarly, Martono and Salam's (2017) meta-analysis, which examined 51 studies from 2000 to 2016, pointed out that structured AODs with clear guidelines and requirements not only increase the number of student posts but also improve the cognitive levels of student posts. Darabi et al.'s (2013) meta-analysis of eight studies from 2000 to 2010 also confirmed the positive relationship between structured AODs and students' online learning performance.

Grading is an essential part of structured AODs. Fehrman and Watson (2021) asserted that graded AODs motivate students to participate in discussions compared to ungraded AODs. Grading has been found to positively affect both the quantity and quality of student posts (Lee & Recker, 2021; Liu & Deris, 2022). McKinney (2018) highly recommended the use of rubrics in grading discussions, as it can bridge the gap between instructors' expectations for student participation in AODs and students' understanding of how to participate effectively. Furthermore, it significantly reduces grading time for instructors, facilitates convenient and specific feedback, and allows students to self-evaluate and revise their posts, thereby decreasing confusion and complaints about grades.

Facilitation Strategies Used in AODs

A variety of facilitation strategies are used in structured and graded AODs, and they are generally classified into two categories: peer facilitation and instructor facilitation (Ahlf & McNeil, 2023). In peer-facilitated AODs, students are usually randomly assigned or volunteer to be discussion facilitators. Their responsibilities include initiating discussions by posting prompt questions related to specific topics, responding to peers' posts by asking probing or clarifying questions and encouraging multiple perspectives, and summarizing discussions by synthesizing all posts and connecting them to the topics (Baran & Correia, 2009; Hylton, 2007). These responsibilities may be handled by a single peer facilitator or distributed among several students in specialized roles such as a starter, moderator, and summarizer (De Wever et al., 2010; Hara et al., 2000; Schellens et al., 2007) and the strategies employed by different roles may vary (Zhong & Norton, 2019). For example, to encourage peers to participate in discussions, the moderator might employ strategies such as acknowledging and commending the contributions of active participants while also encouraging less vocal peers to share their thoughts and perspectives.

Although being a facilitator can enhance students' sense of leadership in discussions (Hara et al., 2000) and increase their effort (Schellens et al., 2007), many studies challenge peer facilitation as less effective than instructor facilitation in AODs. Szabo (2015) found that while peer facilitation led to a higher number of posts, the discussions were more superficial compared

to instructor-facilitated discussions, where students posted longer and higher-quality reflections, evaluations, and applications. Hylton (2007) revealed that compared to peer-facilitated discussions, students had more posts and explicit interactions with peers, demonstrated more high-level cognitive processes (e.g., analysis), and achieved higher course grades in instructor-facilitated discussions. Hew (2015) also stated that most students preferred instructor facilitation to peer facilitation because they believed instructors could provide information from an expert's perspective, keep discussions on track, ensure equity and resolve conflicts, and motivate discussions, especially when students' engagement declined.

To facilitate AODs, instructors apply multiple strategies. The most common strategy is to directly participate in discussions by replying to student posts. Kwon et al. (2019) summarized instructor posts into three categories: elaboration-encouraging, perspective-widening, and praise-oriented. Elaboration-encouraging posts stimulate students to further develop their ideas by asking questions or requesting more information. Perspective-widening posts prompt students to think from multiple perspectives by questioning or challenging their ideas. Praise-oriented posts express approval of student posts and summarize key ideas. They concluded that elaboration-encouraging posts increased the number of student posts, and perspective-widening posts improved the quality of student posts. Clarke and Bartholomew (2014) also classified instructor posts into three categories: cognitive, teaching, and social. Cognitive posts include elaboration-encouraging and perspective-widening posts. Teaching posts focus on providing information from an instructor's perspective, such as personal thoughts, illustrative examples, and additional learning resources. Social posts are similar to praise-oriented posts. This study reported that when instructors balanced the use of cognitive, teaching, and social posts, students demonstrated higher levels of thinking in their posts. In graded discussions, instructors have another option to participate in the discussion. In addition to grading, instructors can comment on student posts on the grade page by providing feedback. Currently, only a few studies have examined this approach as a way for instructors to participate in AODs. However, providing feedback on student posts has been found to positively influence student participation in AODs. Nandi et al. (2012) reported that students relied heavily on instructor feedback in discussions, and regular feedback from instructors improved the quality of student posts, which is also confirmed in Szabo's (2015) study. Szabo explained that providing individualized weekly feedback was more effective than offering weekly feedback to entire discussion groups. Rochera et al. (2021) found that elaboration feedback focused on providing information had an accumulated positive impact on students' knowledge construction in discussions. Interestingly, the timing of instructor participation - whether an active participant in an ongoing discussion or providing feedback afterward - did not significantly affect student participation levels (Arslanyilmaz & Sullins, 2013; Mazzolini & Maddison, 2007). This may be attributed to the chain effect of instructor feedback, whereby feedback provided at the end of one discussion thread can affect subsequent threads (Rochera et al., 2021).

Purpose of the Study and Research Questions

When instructors participate in AODs by directly replying to student posts on discussion boards, their replies become publicly visible, allowing all students to benefit from diverse perspectives. This approach enhances teaching presence in online learning and can improve both the quantity and quality of student participation (Clarke & Bartholomew, 2014; Kwon et al., 2019; Parks-Stamm et al., 2017). Teaching presence is a key element in the Community of

Inquiry (CoI) (Garrison et al., 1999), a framework reflecting the online learning process (Swan et al., 2009). Three indicators of teaching presence are instructional design, facilitating knowledge construction, and direct instruction (Garrison et al., 1999). However, this method can compromise privacy, as students may feel their contributions are exposed to the entire class when instructors' replies are perceived as personal feedback. Additionally, studies have found that direct instructor participation may lead students to focus more on instructors' replies, reducing peer interaction (Nielsen, 2013; Zhao & Sullivan, 2017). Alternatively, when instructors comment on student posts on grade pages, the comments remain private, alleviating concerns about peers accessing feedback, including critical remarks. This approach limits the opportunity for students to learn from instructors' comments on their peers' posts but effectively maintains a distinction between student-student and student-instructor interactions. This separation may help prevent negative impacts on student-student interaction.

Given the advantages and limitations of these two instructor participation approaches, this study aimed to compare their impact on student performance in AODs. Instructor participation in this study is operationally defined as the instructor's involvement in the discussion process, which includes responding to each student's initial post, providing feedback, and continuing to interact with students by revisiting discussion threads to offer additional insights and answer follow-up questions. The key indicators of student performance highly valued by instructors are the quantity of student participation and the quality of student posts (Shi et al., 2023). Therefore, the study addressed the following research questions:

1. How do the two instructor participation approaches in AODs (instructor replies on discussion boards versus comments on grade pages) impact the quantity of student participation?
2. How do these two instructor participation approaches in AODs impact the quality of student posts?

The quantity of student participation includes the number of posts (initial posts and replies), the number of interactions (participants replying to others and vice versa), and the social network patterns among participants. The quality of student posts refers to the level of knowledge construction, such as statements, inquiries, and reflections.

Method

Context and Participants

This study was conducted between January and April 2023 in a fully online course at a major public research university located in the Midwest region of the United States. There were two sections of the same 15-week "Learning and Motivation Strategies for College Success" online course. The course aims to equip first-year and second-year undergraduates with the academic beliefs and habits essential for college success. It was delivered through the institution's branded version of Canvas as the learning management system. Several measures were implemented to control for existing differences. Both sections followed the same course sequence, utilized the same reading materials, addressed identical discussion questions, implemented the same learning activities, and were taught by the same instructor. This consistency allowed for a controlled comparison of the two instructor participation approaches

being investigated. Each section had 25 enrolled undergraduate students, most of whom were between the ages of 18 and 22. Students came from a variety of fields of study, including but not limited to business, psychology, engineering, education, health sciences, and computer science. The majority of these students have had some prior online learning experience, either in high school or college, and were comfortable with technology. All students were required to participate in content-related structured AODs as part of the course's learning activities. There were seven weekly discussion sessions out of the 15-week semester. These discussions were whole class-based and designed to engage students in meaningful dialogue and critical thinking related to the course material. Students were explicitly required to make an initial post and respond to at least one peer's post within each week-long discussion period. Participation in these discussions constituted 21% of students' final grades in the class. Of the 50 students enrolled in the course, 20 voluntarily consented to participate in this study. This included 9 students (6 females and 3 males) from section 1 and 11 students (5 females and 6 males) from section 2. This study was reviewed and approved by the university's Institutional Review Board.

Procedure

The study involved two sections of the same course, with a key difference in how the instructor participated in AODs. In section 1, the instructor replied directly to each student's initial post on the public discussion board, with the instructor's replies visible to all students enrolled in that section. This allowed all students to view the instructor's comments given to their peers. In contrast, for section 2, the instructor provided private comments on each student's initial post through the SpeedGrader™ function on Canvas. This ensured that the instructor's comments were only viewable by the individual student who had posted, and no other students could see the instructor's comments in this section.

Regardless of these differences in participation approach, instructor replies and comments began on Fridays following the weekly discussion deadline on Sundays. This was to allow students more time and the opportunity to revisit their peers' posts and engage in ongoing discussions. Furthermore, in section 1, the instructor actively participated in the ongoing discussion by revisiting threads to provide additional insights and answer follow-up questions, also fostering a continuous dialogue. All other follow-up discussions and the answering of subsequent questions in section 2 occurred in a one-on-one text-based format (e.g., email).

The structure and content of the instructor's feedback remained consistent across both sections. The replies and comments focused primarily on providing instructional information, such as elaboration, heuristic questioning, and suggestions. The comments also incorporated social elements like greetings and compliments. See Appendix A for more details. This combined approach of instructional and social feedback has been shown to be effective in facilitating AODs (Clarke & Bartholomew, 2014; Kwon et al., 2019).

Data Collection and Analysis

This study collected two sets of data for analysis: the initial posts participants made in response to the discussion questions and their subsequent replies to their peers' posts. Instructor replies and comments were not included. It followed a mixed-method approach to compare the effects of two instructor participation approaches in AODs. All data were anonymized, and

participants were assigned random numbers. The data was analyzed using Microsoft Excel, IBM SPSS Statistics (version 29.0.1.0), and Gephi (version 0.10.1).

Quantitative methods were employed to evaluate the quantity of student participation, and these three metrics were measured: (1) the number of text posts (initial posts and replies) made by each participant, (2) the number of interactions associated with each participant, and (3) the quantification of knowledge construction codes. An independent *t*-test was conducted to determine if there was a statistically significant difference between the two sections, as measured by the three metrics. Social network analysis (SNA), a widely used method that graphically reveals the interactions among actors in a social network (Scott, 2000), was conducted to further explore participant interaction patterns in discussions.

The qualitative method included a content analysis to assess the quality of students' text posts on discussion boards in terms of the level of knowledge construction, which is closely related to cognitive engagement and widely used as an indicator of the quality of discussion posts (e.g., Kwon et al., 2019; Lee & Recker, 2021; Zhao & Sullivan, 2017; Zhu, 2006). Like the cognitive processes in Bloom's revised taxonomy (Anderson et al., 2001), knowledge construction in discussions has ordered levels. Higher levels indicate higher knowledge construction, representing higher post quality. This qualitative approach involved the following steps:

1. Segmentation: The first step was to divide all participant posts into smaller meaning units. These units could range from single words to multiple sentences as long as each unit conveyed a single, coherent idea (Kleinheksel et al., 2020). This segmentation process ensured that the analysis captured the granularity of the posts.
2. Coding Framework: A coding framework (Appendix B) from Kwon et al.'s (2019) study was adopted to guide the analysis. However, the framework was modified to incorporate relevant elements from other related studies (Zhao & Sullivan, 2017; Zhu, 2006). This adaptation ensured that the coding framework was aligned to the specific context of the study. It also provided a more structured way to categorize and interpret the meaning units derived from the participants' posts.
3. Initial Coding and Reliability: After agreeing on the procedure and the various codes in the coding framework, the first two authors independently coded 20% of the posts from the two discussion boards. This initial coding was done independently to minimize potential biases and set the tone for objectivity throughout the procedure. Following a comparison of codes and reaching a consensus, the authors resumed their independent coding of the remaining posts. An initial inter-rater reliability was calculated at 90.5%. Any discrepancies or disagreements in the coding decisions were discussed until the researchers reached 100% agreement.
4. Quantification: The qualitative data derived from the meaning units was quantitatively measured and analyzed once the coding process was complete. This quantification allowed for comparisons and inferences to be made about the quality of student posts based on the established coding framework.

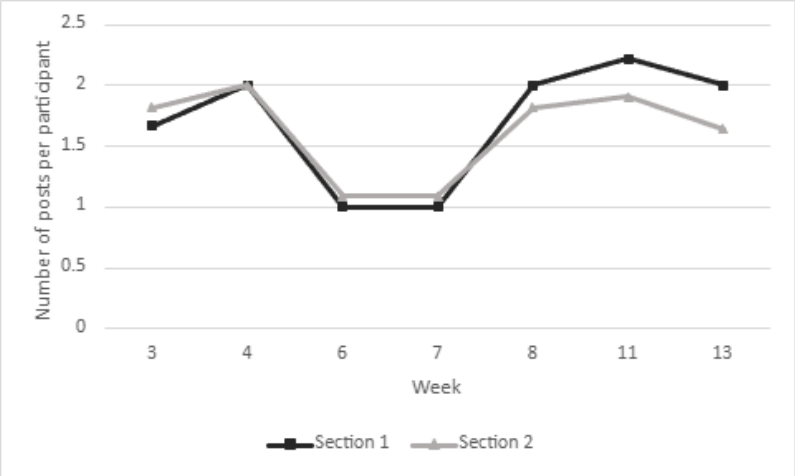
Results

The Number of Posts

A total of 107 participants' text posts were recorded in section 1 (instructor's replies on public discussion boards), and 125 participants' text posts were recorded in section 2 (instructor's comments on private grade pages). The average number of posts per participant per week was marginally greater in section 1 (M = 1.70, SD = .50) compared to section 2 (M = 1.62, SD = .38). Additional details can be found in Figure 1. The notable drop in the number of posts observed in weeks 6 and 7 across both sections was attributed to the fact that the initial posts for those weeks were in the form of uploaded files rather than discussion board text. An independent t-test was conducted to compare the number of posts between the two sections. The results showed that the difference was not significant ($t(12) = .315$, $p = .759$). This suggests that the different instructor participation approaches did not significantly affect the overall posting frequency of students in AODs.

Figure 1

Number of Posts Per Participant Per Week



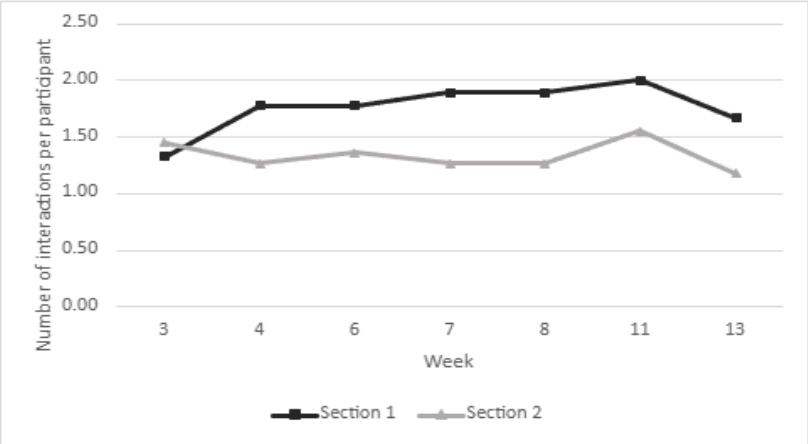
Note. Section 1: The instructor replied to student posts on public discussion boards. Section 2: The instructor commented on student posts on private grade pages.

The Number of Interactions

There were a total of 111 interactions in section 1 and 103 interactions in section 2. Since interaction refers to the behavior of participants replying to others (participants and non-participants) and others replying to participants, as expected, the number of interactions exceeded the number of posts. The average number of interactions per participant per week was higher in section 1 (M = 1.76, SD = .22) compared to section 2 (M = 1.34, SD = .13). Additional details can be found in Figure 2. The results of the independent t-test showed that the difference in the number of interactions was statistically significant ($t(12) = 4.479$, $p < .001$), with a large effect size (Cohen's $d = 2.394$). This suggests that when the instructor directly replied to students on public discussion boards (section 1), there were significantly more interactions between students compared to when the instructor provided comments privately to the students on the grade pages (section 2).

Figure 2

Number of Interactions Per Participant Per Week



Note. Section 1: The instructor replied to student posts on public discussion boards. Section 2: The instructor commented on student posts on private grade pages.

Social Network Patterns

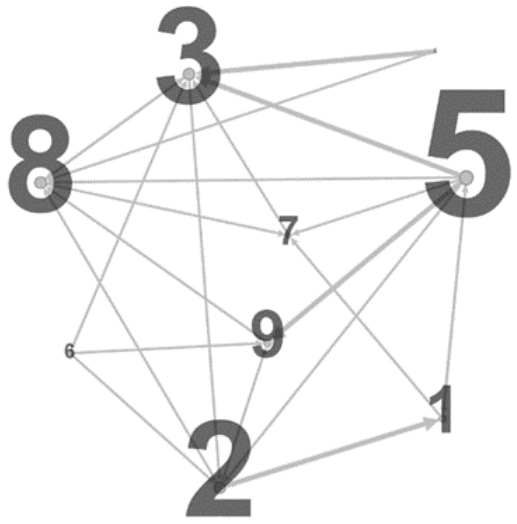
The interaction between participants in each section over the 7 weeks was presented through a directed social network, as shown in Figures 3 and 4. Each participant was represented by a number, which is the node in the network. Consequently, section 1 (instructor's replies on public discussion boards) had 9 nodes, and section 2 (instructor's comments on private grade pages) had 11 nodes. The size of the nodes was ranked by their degree, including in-degree and out-degree. In this study, in-degree refers to one participant receiving a reply from another participant, while out-degree refers to one participant replying to another participant. In section 1, participant #5 had the largest degree ($k_5 = 8$), followed by participants #2, #3, and #8 ($k_{2,3,8} = 7$). Participant #4 had the smallest degree ($k_4 = 2$). In section 2, participant #2 had the largest degree ($k_2 = 9$), followed by participants #1, #5, and #10 ($k_{1,5,10} = 7$). Participant #8 had the smallest degree ($k_8 = 1$). The average degree was 2.67 in section 1 and 2.55 in section 2. The lines with arrows between nodes are called directed edges (Tabassum et al., 2018). There were 24 edges in section 1 and 28 edges in section 2. The thickness of the edges was determined by their weight. One interaction equals 1 weight. Thicker edges mean more interactions between the two participants. The maximum weight in both sections was 2.

Closeness centrality and betweenness centrality are two important metrics in SNA. The former measures how quickly a node can reach other nodes in the network, while the latter measures the degree to which a node is situated between other nodes in the network (Tabassum et al., 2018). In the discussion context, the smaller the closeness centrality value is, the fewer people the connection between a participant and other participants passes through, meaning that the participant is more closely connected to others. The greater value of betweenness centrality means that the participant is in a key position in the discussion, connecting different participants (Tabassum et al., 2018). The closeness centrality value of participants ranged from 0.4 to 1.0 in section 1 and from 0.29 to 0.6 in section 2, suggesting that the participants in section 2 were more closely connected. In section 1, participant #2 had the largest betweenness centrality value ($b_2 = 14.73$), followed by participant #3 ($b_3 = 13.53$) and participant #8 ($b_8 = 5.1$). Participants #4 and #6 had the smallest betweenness centrality value ($b_{4,6} = 0$). In section 2, participant #10 had

the largest betweenness centrality value (b_{10} = 32.5), followed by participant #1 (b_1 = 23.67) and participant #4 (b_4 = 19.5). Participants #11, #9, and #8 had the smallest betweenness centrality value ($b_{11,9,8}$ = 0). This indicates that the participants who acted as connectors in section 2 connected more participants, making the discussion more interactive. Density is another critical metric in SNA, which is defined as the ratio of the number of actual edges to the number of all possible edges (Tabassum et al., 2018). The greater value of density means denser interactions in the discussion. It was 0.33 in section 1 and 0.26 in section 2.

Figure 3

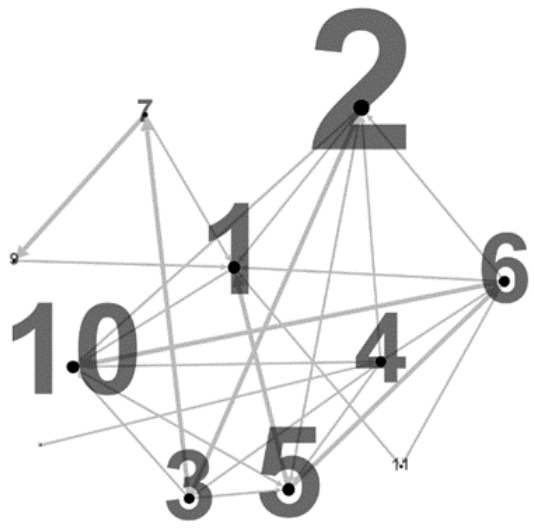
Social Network Pattern in Section 1



Note. Section 1: The instructor replied to student posts on public discussion boards.

Figure 4

Social Network Pattern in Section 2



Note. Section 2: The instructor commented on student posts on private grade pages.

Knowledge Construction

The content analysis examined the frequency of different knowledge construction codes in student posts across the two sections. Section 1 exhibited a slightly higher frequency of statement, inquiry, exploration, and evaluation codes, while section 2 demonstrated a slightly greater emphasis on elaboration, synthesis, and reflection codes (Table 1). However, the independent *t*-test results revealed that the differences in the frequencies of all codes between the two sections were not statistically significant ($p > .05$). This finding indicates that the quality of student posts, as measured by the knowledge construction codes, was at a similar level regardless of whether the instructor provided public replies on discussion boards or private comments on grade pages.

Table 1

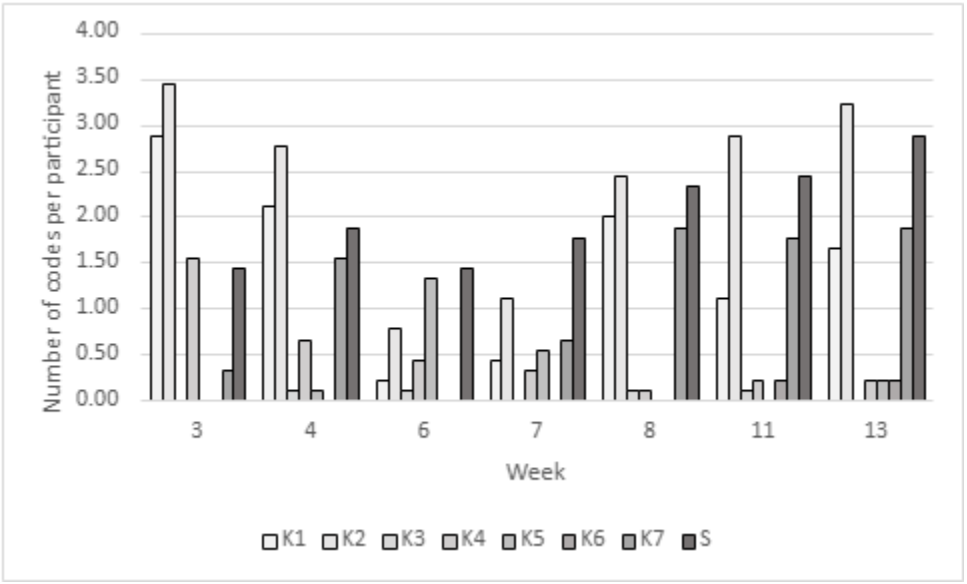
Descriptive Statistics of Knowledge Construction Codes in Student Posts

	Section 1			Section 2		
	Number of Weeks	*M*	*SD*	*Number of Weeks*	*M*	*SD*
Statement (K1)	7	1.49	.96	7	1.09	.79
Elaboration (K2)	7	2.38	1.04	7	3.19	1.24
Inquiry (K3)	7	.06	.06	7	.04	.07
Exploration (K4)	7	.51	.50	7	.30	.41
Evaluation (K5)	7	.32	.49	7	.22	.36
Synthesis (K6)	7	.06	.11	7	.09	.07
Reflection (K7)	7	1.16	.80	7	1.81	1.17
Social communication (S)	7	2.03	.54	7	2.12	.52

The average number of codes per participant per week was analyzed to further understand the progression of knowledge construction over time. It was found that the proportion of higher-level knowledge construction codes, such as evaluation, synthesis, and reflection, gradually increased in both sections as the course progressed. See Figures 5 and 6 (the bars followed the order of the labels at the bottom, from left to right). This trend suggests that the quality of student posts improved over time, with students engaging in more cognitive processes as the discussions continued (Garrison et al., 2001) and the instructor remained actively involved. The presence of instructor participation, whether through public replies or private comments, likely facilitated more knowledge construction among students. It is also worth noting that when the instructor provided comments on grade pages, the proportion of social communication codes in student posts gradually decreased over time (Figure 6). This finding implies that when the instructor's feedback was private, the focus of student posts shifted toward knowledge construction rather than social aspects as the course progressed.

Figure 5

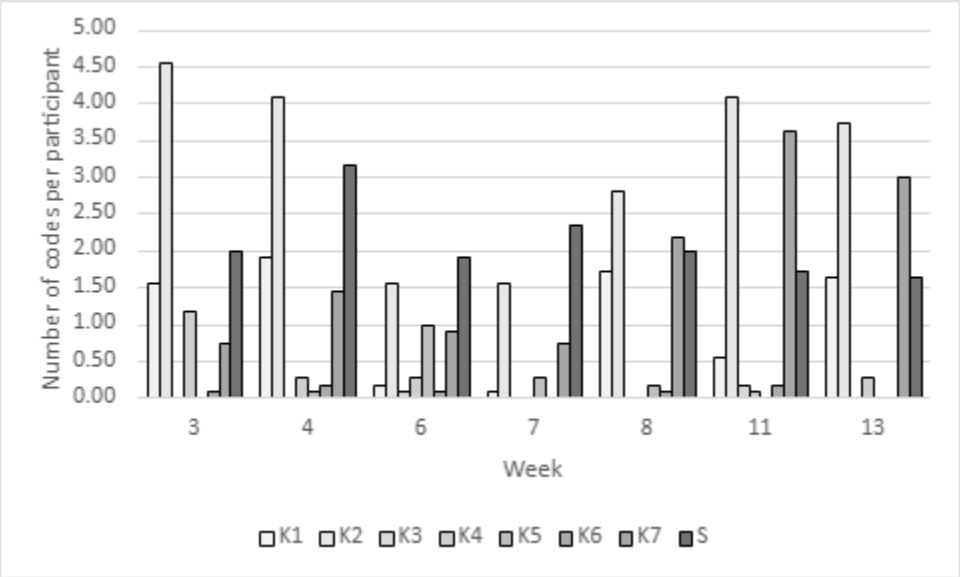
Number of Codes Per Participant Per Week in Section 1



Note. Section 1: The instructor replied to student posts on public discussion boards. K1: Statement, K2: Elaboration, K3: Inquiry, K4: Exploration, K5: Evaluation, K6: Synthesis, K7: Reflection, S: Social communication.

Figure 6

Number of Codes Per Participant Per Week in Section 2



Note. Section 2: The instructor commented on student posts on private grade pages. K1: Statement, K2: Elaboration, K3: Inquiry, K4: Exploration, K5: Evaluation, K6: Synthesis, K7: Reflection, S: Social communication.

Discussion

The Quantity of Student Participation

In the context of this study, the quantity of student participation included the number of posts, the number of interactions, and the social network patterns students made in AODs. The first research question investigated how the two instructor participation approaches impacted this quantitative dimension of student participation. The findings reported no significant difference in the number of posts between the two sections, suggesting the approach of instructor participation did not impact the frequency of student posting. This aligns with the statement that instructor participation does not impact the number of student posts in medium-sized classes (15–30 students) (Parks-Stamm et al., 2017), as each section in this study had 25 students. The course design and the assessment criteria might also influence student participation. Since participation in discussions accounted for 21% of students' final grades, the grading incentive could motivate students to meet the required posting frequency, irrespective of the instructor's participation approach. Another possible reason could be explained by the time of instructor participation. The instructor in the study replied to or commented on student posts after the discussion deadline rather than in the middle of discussions, which might not inspire students to post.

A significant difference in the number of interactions was found between the two sections. A higher number of student-student interactions occurred when the instructor replied on discussion boards compared to commenting on grade pages. This may be because the instructor's replies on discussion boards were more prominent and easily noticed by students. Public instructor visibility creates a perception of higher engagement, motivating students to interact with each other (Xu et al., 2020). The higher interaction level aligns with previous studies emphasizing the importance of overt instructor participation for cultivating an interactive online learning environment (Blignaut & Trollip, 2003; Mazzolini & Maddison, 2003). When instructors visibly participate, it can stimulate and sustain student-student interactions in ways that less visible participation does not (Dennen, 2005). This finding is contrary to the claim that instructors' direct participation in AODs negatively affects interactions between students (Nielsen, 2013; Zhao & Sullivan, 2017). It may be because the instructor participated after discussions were over, thus not making discussions instructor-centered. Regarding social network patterns, both sections had an interconnected web instead of a star web, indicating that the interaction among students was relatively balanced and no single student dominated the discussions (Zhu, 2006). The values of average degree and density in section 1 (instructor's replies on public discussion boards) were greater than in section 2 (instructor's comments on private grade pages), indicating that participants were more interactive when the instructor replied on discussion boards, which echoes the result found in the number of interactions.

The Quality of Student Posts

The content analysis revealed similarities and differences in the knowledge construction exhibited by participants across the two sections with different instructor participation approaches in AODs. While the frequency of the various knowledge construction codes was not significantly different between sections, indicating that the overall quality of student posts in the two sections was similar, the analysis revealed some subtle differences. In both sections, higher-order cognitive processes like evaluation, synthesis, and reflection became more prevalent in student posts as the course advanced. This aligns with existing research showing that sustained instructor participation can scaffold increasingly complex levels of knowledge construction over time (Anderson et al., 2001; Garrison et al., 1999). Other studies have also reported a positive relationship between instructor participation in AODs and the quality of student posts (Clarke & Bartholomew, 2014; Kwon et al., 2019; Szabo, 2015; Xu et al., 2020). Overall, student posts focused more on statement, elaboration, and reflection than inquiry, exploration, evaluation, and synthesis. This could be caused by the guidelines set in discussions. Most of the prompt questions asked in discussions were "what" questions (e.g., "What can you do to influence your own motivation?"), and the requirement for replies only asked students to add encouragement and additional ideas to their peers' posts, which might be difficult to promote posts that include inquiry, exploration, evaluation, and synthesis. Another interesting finding in the study was that the number of social communication codes decreased over time in section 2. This could be a result of students perceiving the instructor's comments on grade pages as more targeted and academically focused, leading them to prioritize content-driven discussions over social communications.

Implications for Research and Practice

Previous studies on instructor participation in AODs often overlooked the different approaches by which instructors can engage. These studies predominantly assumed that instructors participated by directly replying to student posts on discussion boards. In contrast, this study introduced an alternative instructor participation approach: commenting on student posts on grade pages. By comparing the impact of these two approaches on student performance, this research expanded the existing body of knowledge on effective strategies for facilitating AODs. Moreover, the discussion content analysis framework proposed in this study offers a robust tool for coding student posts, which can be employed in future research to further explore and validate these findings.

For instructors, the findings provided valuable insights into how different participation strategies can influence student participation and learning outcomes in AODs. Specifically, if the goal is to enhance student interaction and peer communication, instructors could focus on replying directly to student posts on discussion boards. Conversely, if the objective is to foster deeper knowledge construction rather than social interaction, commenting on student posts on grade pages proves to be more effective. Regardless of the approach chosen, instructor participation in AODs is of critical importance. Instructor active participation significantly benefits student performance (Xu et al., 2020). Additionally, the structured approach to instructor replies and comments provided in this study can serve as a practical guide for instructors. By following the example set out in the study, instructors can ensure their participation is both meaningful and constructive, further enhancing the educational value of AODs.

Limitations of the Study and Future Research

While this study provided valuable insights into AODs, it is crucial to acknowledge its limitations. This study was confined to two sections of a single online course with structured and graded AODs. This specific context restricted the broader applicability of the findings. Different courses, disciplines, and instructional styles might yield different results. The relatively small sample size and short duration of the study further limited the generalizability of the results. Since not all students agreed to participate in this study, the results did not reflect the entire discussion. Therefore, future research is encouraged to expand the scope by including multiple courses with different types of AOD, larger sample sizes, and longer intervention periods. Obtaining the consent of all students participating in the discussion will make the research findings more robust. Including a control group without instructor participation in AODs may be beneficial. This can help fully isolate and understand the specific effects of the different instructor participation approaches on student performance. Additionally, the study focused on objective data and did not consider students' subjective experiences and satisfaction with different instructor participation approaches. An understanding of students' preferences and perceptions could be crucial for refining and optimizing participation strategies.

Exploring the use of artificial intelligence (AI) to help instructors facilitate AODs is a promising direction. In this study, the instructor spent a lot of time providing regular feedback to individuals and grading posts, even for two medium-sized classes, let alone large courses. AI can assist in identifying posts that need feedback by classifying posts by urgency (Almatraf et al., 2018) and confusion level (Du & Xing, 2023), extracting discussion topics (Chen et al., 2021), and providing timely and relevant feedback (Zheng et al., 2021). With the help of AI, instructors can not only have a comprehensive understanding of specific aspects of discussions but also

quickly provide feedback on the posts that require instructor replies, which can greatly improve the efficiency and effectiveness of instructors in facilitating AODs, leading to better student learning experience and performance

AI is also capable of grading student posts based on embedded rules (Archibald et al., 2023; Butcher et al., 2020; Cheong et al., 2019). If the rules are consistent with the discussion grading rubrics, the AI-generated post scores can be directly used as students' discussion grades. This direct use of AI-generated scores can significantly reduce the time instructors spend on grading, allowing them to focus more on providing qualitative feedback and facilitating deeper discussions. Besides, AI-generated post scores have been shown to effectively encourage students to improve their posts by fixing grammatical errors, revising sentence structures, using examples to clarify their ideas, and adding citations to support their statements (Archibald et al., 2023; Butcher et al., 2020; Cheong et al., 2019). This feedback mechanism not only aids in the development of students' writing skills but also promotes critical thinking and better participation in discussions. However, accuracy, fairness, and ethical issues should be carefully considered before applying AI in AODs.

Conclusion

This study examined how different instructor participation approaches impact student performance in asynchronous online discussions. The findings indicate that while the frequency of student posts was not significantly affected by the instructor's participation approach, the number of student-student interactions was significantly more when the instructor visibly participated on discussion boards. This visible participation fostered a more interactive learning environment. Additionally, both sections showed similar overall quality in student posts, with increased higher-order cognitive processes over time, suggesting that sustained instructor participation supports complex knowledge construction. These findings emphasize the importance of strategic and visible instructor participation in enhancing student interaction and cognitive skill development in online discussions. However, instructors must balance their involvement to avoid overwhelming or dominating the discussions, which could stifle student autonomy and interaction. Some effective strategies, such as posing thought-provoking questions, providing timely feedback, and highlighting exemplary posts, can encourage deeper analysis and peer interaction. Additionally, instructors should model critical thinking and respectful discourse, demonstrating how to constructively critique ideas, synthesize information, and build upon others' contributions.

Declarations

The authors declare no conflicts of interest. The authors declare no funding for this research. Permission to collect data from human subjects was approved by the Ohio State University IRB (Number: 2022B0427).

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Appendix A

An Example of Instructor Reply on a Discussion Board

"Hi [redacted] (**Greetings**). It's understandable that despite being prepared, you still feel anxious and overthink things during exams. An idea from Chapter 11 that you mentioned is arriving slightly closer to the start time of the exam. By giving yourself less time to dwell on your thoughts and second-guess your knowledge, you may be able to ease some of the anxiety (**Elaboration**). However, it's important to note that test anxiety can vary from person to person, so it may be helpful to explore additional strategies or techniques to manage your anxiety (**Suggestion**). Have you considered trying some relaxation exercises?" (**Heuristic Questioning**)

Appendix B

Code Framework for Content Analysis

Category (code)	Subcategory (code)	Description
Knowledge construction (K)	Statement (K1)	Simply stating facts, opinions, and other information related to the discussion topic without elaboration.
	Elaboration (K2)	Elaborating a statement with details, examples, explanations, evidence, and arguments.
	Inquiry (K3)	Asking questions to promote the discussion.
	Exploration (K4)	Exploring an idea from multiple perspectives.
	Evaluation (K5)	Evaluating or criticizing the statements, opinions, and arguments in the discussion, and/or providing suggestions or recommendations for improvement.
	Synthesis (K6)	Synthesizing or connecting different ideas in the discussion.
	Reflection (K7)	Reflecting on one's own learning or behavior in the discussion.
Social communication (S)		Communicating with others by greeting, expressing agreement, compliments, wishes, or thanks, or sharing personal life or other information unrelated to the discussion topic.